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FRAGMENTS DISTRIBUTION PREDICTION FOR ENVISAT CATASTROPHIC FRAGMENTATION

Abstract

The unexpected mission termination of ENVISAT in 2012 suddenly created a new hazard in the already critical Low Earth Orbit (LEO) debris environment: the significant mass (more than 7 tons) and the long natural decaying time (more than 150 years) makes ENVISAT one of the largest and most dangerous debris in LEO at present. In fact, a catastrophic collision would generate and scatter fragments into altitudes occupied by many operational satellites. In this context, simulating the outcomes of possible collision scenarios involving ENVISAT will support the risk evaluation for the involved orbital region, as well as for potential debris spread to other orbits. To this end, the generation of realistic fragment distributions would remarkably increase the accuracy of predictive models for the evolution of space debris environment.

This paper presents the results of a campaign of hypervelocity impacts simulations with ENVISAT as target body. Simulations are performed with a new semi-empirical tool, called CST, which key features are the capability of modelling a large variety of collision scenarios and the possibility to provide statistically accurate results with a computational effort orders of magnitude lower than hydrocodes. For this study, a set of possible collision scenarios are simulated, varying the impacting body (small-class 100 kg satellite, defunct rocket stage) as well as the impact point (glancing impact on ENVISAT radiator, collision on the central body); for each impact configuration, fragments distributions are reported and the severity of the event is discussed.

The distribution of debris fragments in terms of area-to-mass ratio and orbital elements of the fragments is then used as initial condition for the long-term propagation of the debris cloud generated by the fragmentation event. The method used for cloud propagation is a continuum approach that integrates the equations of motion of the dynamics under the effect of perturbations, together with the variational equation of the density of debris fragments in the phase space of orbital elements. The fragment evolution is then superimposed to the whole distribution of space debris fragments to study the effects such a fragmentation would have on the environment. This is achieved by adding ENVISAT fragments population to the ESA Meteoroid and Space Debris Terrestrial Environment Reference (MASTER) one without

considering feedback effects. For each simulated configuration, local distribution peaks are detected and propagated with time, and the general deterioration trend of the space debris environment is discussed.